Forecast on China's Urbanization

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Abstract-**In order to define the future development trend of urbanization in China, this paper employed regression analysis method to study the urbanization system force and market power. Then we can derive the locus equation of the ratio of urbanization and simulate the development trend of urbanization in China. The conclusions of this paper are: The average growth rate of China's urbanization from 1978 to 2009 is 103%; this rapid development will continue until 2013; the results show the sequential growth rate will gradually slow down after 2013; the ultimate urbanization rate in China is 83%, and it will be reached in 2158. After that, the ratio of urbanization will decline. The results of this research will provide meaningful policy suggestions for Chinese government in decision making about development of urbanization in China.**

Keywords-urbanization rate; system power; marketability; locus equation; forecast model

I. INTRODUCTION

Market economy has been progressively realized and the barriers in urban and rural area have been broken since China's reform and opening up. Urbanization rate increased from 17.9% to 46.6% in the last three decades [1]. So we know the development is very rapid .But then level of urbanization in China is much lower than the 85% level in developed countries. That means it has plenty of room for future development. Pan jiahua etc.(2010) predicted that China's urbanization rate in 2015 would reach 52%, in 2030 to 65%, 75% by 2050. The United Nations estimated that by 2050 the urbanization rate would be 86% in developed countries and 72.9% in China [2], [3]. These projections are based on statistical results, and do not show prediction mechanism and the limit of urbanization. So the paper analyzes the limit of China's urbanization rate and the time to reach the limit.

What is driving force for the promotion of urbanization Some scholars believe that it is economic development [4] and others is the development of agriculture, industrialization, marketability [5] etc. The paper argues the systems (policies, measures, etc.) power besides marketability. Marketability is the ability of urban population accepted and the ability of people into cities. These two forces are imbalance. System power is the government's urbanization policy, measures to regulate the balance of market power and to control the process of urbanization. Its performance in 30 years of reform and opening are: to improve the capacity of the population to accept the town (such as develop small towns etc), to set the "threshold" (which gradually reduce) to control people into cities. With mechanics, regression analysis and analytic geometry, the paper researches the equation with system power and marketability, derives locus equation on future changes in urbanization. All these conclusions will provide reference for city development and government decision, and also provide methodology information for similar research.

II. THE PROGRESS OF URBANIZATION DURING THE 30 YEARS' REFORM AND OPENING UP

Urbanization has experienced three stages after the reform and opening in 1978: the first decade is recovery stage; the second decade is developing small towns vigorously (the newly-increased cities in 1997 reached 452, the number has been doubled compared with the cities in 1979.); and the scale of the cities have been expanded rapidly and the urban population increased quickly during the third decade. The urbanization rate is 17.92% in 1978, and increased to 46.59% in 2009, the average growth rate was 103 % ($\sqrt[32]{\frac{46.59}{17.92}} = 103\ \%$).The main means of promoting urbanization are expanding the scale of cities, enhancing the quality of cities, and strengthening the functions of cities. The meaning of urbanization in this paper is population urbanization, and it is represented by the proportion of urban population of the total population.

A. The Increase of Urbanization Rates in the Reform of The Household Registration System

The household registration system experienced three stages since the reform and opening up: first, eliminating barriers between urban and rural area and then relaxing the household registration control; second, cancelling household control and promoting farmers to enter into cities as peasant workers; third, encouraging farmers to move into cities to become city people. Then urbanization was realized by the reform of household registration system. The reform of the household registration system was caused by market economy and then led to urbanization during the steady transition from planned economy to market economy. Cities were unable to stand the

heavy burden in the beginning of reform and opening up (1978 ~ 1984) because the Rusticated Youth of China and the Rusticated Cadres went back to cities and the heavy demand of farmers' transfer to cities. Worse still, the urbanization is underdeveloped at that time. The household registration control was still strict at that time, so urbanization was developed smoothly under the economic system.of the day. The rigid household registration system began loosening in 1984, and farmers with self-supplied food were allowed to settled in the towns that administrated by counties. Then it met the need that the farmers wanted to work at factories and live in cities. With the economic boom and rapid development of small towns in 1990s and the demand for labor increasing substantially in urban area, at the same time, a large number of surplus labors appearing in rural area, then government adjusted the household registration system in time and allowed the peasants who had been employed or lived in small cities or towns as permanent residence. Many small cities have broken the residence restrictions, and many big and middle cities have released the restrictions on outlander who wanted to enter cities. The separation of urban and rural registration system was reformed and abolished after 2000.The people, who have legal permanent residence, or a stable job or source of income or living together with his immediate family members in the county-level cities, or the town where the county government resident in or others, can be registered to become permanent residence; The blue-print account, local urban residents accounts and the accounts with self-supplied food, which were registered in small towns, were registered as the urban residents. Some places even encouraged peasants to live and start businesses in small towns. At the present, the administration of house registration in Chongqing and Chengdu city has been centralized and the peasants are encouraged to become city people from peasants. The reform of household registration system has been playing a role of leverage to urbanization, then the urbanization is developed smoothly (see table 1). Therefore, it is reasonable to admit that system force works in the process of urbanization, because system force is from economic development which is from the policy of reform and opening-up.

B. The Regression Equation of Urbanization Rate and Time Over 30 Years after Reform and Opening

System force is an artificial force which is necessary in transformation in the reform of economic system, and it is also indispensable in the full market economy. This force has made the urbanization rate increase steadily and continued.

Fig. 1 shows that the urbanization rate is distributed roughly in a straight line, so a linear equation is choosed ($y=kx+b$) to simulate the regression. Set x as time, the y as urbanization rate, 1977 is the 0 points. $x\in[1,30]$. (The later equation is same).

Then the regression can be showed as following according to least square method

$$y=0.899818x+15.77683 \quad (1)$$

The standard deviation $s_y \approx 1.518$, $\frac{s_y}{\bar{y}} \approx 0.05 < 15\%$. After check, $p=0$. So the model can fit this change effetely. Formula (1) shows that the annual rate of growth of urbanization rate is 0.899818 percent during last 30 years. Formula (1) reflects the rule that urbanization rate change after reform and opening very well, then can we use this rule of trend to extrapolate? The answer is no. Because the system force is significant in the transition period, and with the improvement of the market mechanism, the role of market force will become even more important. Therefore, a new way should be found to forecast the future urbanization.

TABLE Ⅰ. THE PROCESS OF URBANIZATION DEVELOPMENT IN CHINA DURING 1978~2009UNIT:%

year	1978	1979	1980	1981	1982	1983	1984
Urbanization rate	17.92	18.96	19.39	20.16	21.13	21.62	23.01
Year	1985	1986	1987	1988	1989	1990	1991
Urbanization rate	23.71	24.52	25.32	25.81	26.21	26.41	26.94
year	1992	1993	1994	1995	1996	1997	1998
Urbanization rate	27.46	27.99	28.51	29.04	30.48	31.91	33.35
year	1999	2000	2001	2002	2003	2004	2005
Urbanization rate	34.78	36.22	37.66	39.09	40.53	41.76	42.99
Year	2006	2007	2008	2009			
Urbanization rate	43.90	44.94	45.68	46.59			

Data source: China Statistic Yearbook, 1979~2010

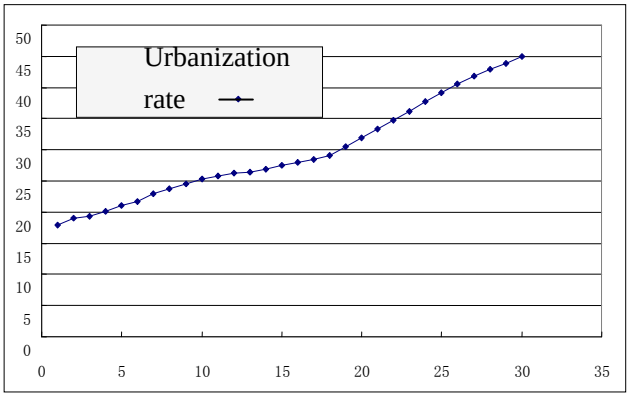

Fig. 1 The scatter diagram of Urbanization over time during 1978~2007

III. RESEARCH ON THE POWER OF URBANIZATION

System force (visible force) tries to raise urbanization rate linearly; while market forces (invisible force) tries to raise urbanization rate to its limit. Line has no boundary, but the urbanization rate is bounded (this bound less than 100%). The diminishing marginal urbanization rate indicates that the locus equation of market force is an elliptic equation. The tangent of this ellipse is the direction of market force. The locus equation of urbanization rate is neither straight line nor ellipse; it's the trajectory of resultant from market forces and system forces. Then the function of this trajectory as following:

A. Set of Coordinates

By the urbanization rate for the x-axis, with time (year) for the y-axis and set time of 1977 as zero, coordinates is set as in figure 2.

$$y = kx + b \tag{2}$$

The function of market force is an elliptic function. We assume the semi-major axis of ellipse is a, the semi-minor axis is A-b (A is the limit of the urbanization), the center of this ellipse is (a,b). The corresponding elliptic function can be written as $(\frac{x}{a}-1)^2+(\frac{y-b}{A-b})^2=1$, rearrange this equation we get:

$$y=\frac{A-b}{a}\sqrt{2ax-x^2}+b \tag{3}$$

B. Tangential Equation

Market force can be represented by an elliptic equation, and its direction is the tangent direction of the ellipse. The magnitude and direction of market force changed over time. Suppose the coordinates of arbitrary point on this ellipse is $B(x_0,y_0)$, the tangential function of *B* can be obtained by using point slope form. The slope of tangent of the ellipse at *B* is the derivative of ellipse at *B*. The derivative of ellipse at *B* is:

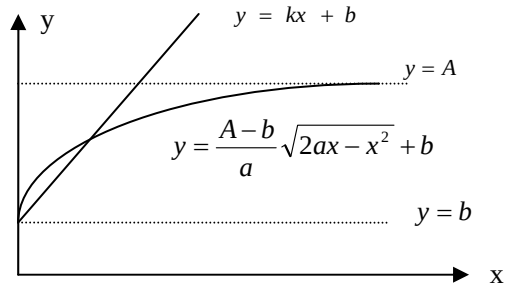

Fig. 2 Coordinate map of institutional man market force

$$y_0' = \frac{A-b}{a}\frac{a-x_0}{\sqrt{2ax_0-x_0^2}} \tag{4}$$

By using point slope form we can obtain the tangential function of ellipse at *B* (as shown in figure 3):

$$y=\frac{(A-b)}{a}\frac{(a-x_0)x+x_0}{\sqrt{2ax_0-x_0^2}}+b \tag{5}$$

tangent line *DC* intersect with line *y=A* at $C(\frac{a\sqrt{2ax_0-x_0^2}-ax_0}{a-x_0},A)$, *DC* intersect with *y=kx+b* at:

$$D(\frac{(A-b)ax_0}{ak\sqrt{2ax_0-x_0^2}-(A-b)(a-x_0)},\frac{k(A-b)ax_0}{ak\sqrt{2ax_0-x_0^2}-(A-b)(a-x_0)}+b)$$

C. Resultant Function

The institutional function *y=kx+b* intersect with $y=A$ at $F(\frac{A-b}{k},A)$. The midpoint of *FC* is $E(\frac{(A-b)(a-x_0)+ka\sqrt{2ax_0-x_0^2}-x_0}{2k(a-x_0)},A)$.

According to parallelogram law in mechanics, the resultant line of DC and DF must cross the midpoint E of FC. So DE is the resultant line of system force and market force at time x_0. By using two point form we can get the function of DE as:

$$y=\frac{[2k(a-x_0)x+kax_0][ak\sqrt{2ax_0-x_0^2}+(A-b-ak)x_0-a(A-b)]}{a[\frac{2k^2a^2}{A-b}+2(A-b)-ak]x_0-(\frac{a^2k^2}{A-b}+A-b-ak)x_0^2-\frac{a^2k^2}{A-b}x_0\sqrt{2ax_0-x_0^2}-a^2(A-b)}+b \tag{6}$$

D. Moving Point of Urbanization Rate

When urbanization rate reaches to y_0, the time for the system force to reach y_0 is x_H, and the time for resultant to reach y_0 is x_G, and the time for the system force to reach y_0 is x_0. As shown in figure 4, $x_H < x_G < x_0$.

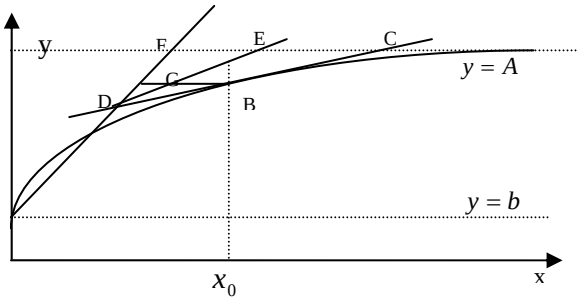

Fig. 3 Diagram of the direction of system forces, market forces and resultant

The coordinate of point H is $H(\frac{y_0-b}{k}, y_0)$ or $H(\frac{(A-b)\sqrt{2ax_0-x_0^2}}{ak}, \frac{(A-b)\sqrt{2ax_0-x_0^2}}{a}+b)$. The resultant line must pass through midpoint *G* of *HB*. The coordinate of *G* is $G(\frac{(A-b)\sqrt{2ax_0+x_0^2}+akx_0}{2ak}, y_0)$.

G is a moving point and will vary with the change of *B*. The locus of *G* is the locus of urbanization rate. The locus equation of *B* can be written as:

$$y = f(\frac{(A-b)\sqrt{2ax_0 - x_0^2} + akx_0}{2ak})$$

or substituted into equation (6):

$$y=\frac{[\frac{(A-b)(a-x)\sqrt{2ax-x^2}}{a}+2akx-kx^2][ak\sqrt{2ax-x^2}+(A-b-ak)x-a(A-b)]}{d[\frac{2k^2a^2}{A-b}+2(A-b)-ak]x-(\frac{a^2k^2}{A-b}+A-b-ak)x^2-\frac{a^2k^2}{A-b}x\sqrt{2ax-x^2})-a^2(A-b)}+b \quad (7)$$

when $x \to a$, G tending to close to $G(\frac{A-b+ka}{2k}, A)$.

IV. URBANIZATION TREND EQUATION

As we have discussed above, the direction of market force is the tangent of ellipse, and the parameter a of the ellipse equation can be obtained as follows:

Rearrange the ellipse equation we get: $1-\sqrt{1-(\frac{y-b}{A-b})^2} = \frac{x}{a}$

Make $\frac{\partial \sum[(1-\sqrt{1-(\frac{y-b}{A-b})^2}-\frac{x}{a}]^2}{\partial a} = 0$, then

$$a = \frac{\sum x^2}{\sum x - \sum x\sqrt{1-(\frac{y-b}{A-b})^2}}$$

because $x \in (1,2,\cdots,n)$, a can be rewritten as:

$$a = \frac{\frac{1}{6}n(n+1)(2n+1)}{\frac{1}{2}n(n+1) - \sum x\sqrt{1-(\frac{y-b}{A-b})^2}} \quad (8)$$

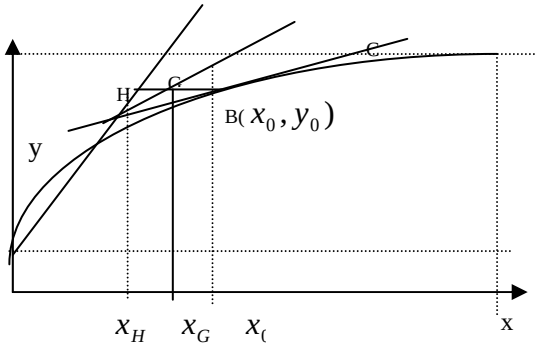

Fig. 4 In the same urbanization level, system force, resultant and market force time lag diagram

If A=100, then according to the data of the ratio of urbanization per year from 1978 to 2007 and the number of *b*, we can get, $a = 726.7858$. But A can't be equal to 100 because the ratio of urbanization can't reach 100% in reality. Hereafter we study the limit of A so we can calculate the parameters in equation (7) and build up the urbanization trend equation and make forecast.

A. The Limit of Urbanization

As shown in Fig. 5, together with the change of tangent line, there must be one and only one resultant line which crosses the point $Q(x_0, A)$. The abscissa of *Q* is also the abscissa of the tangent point of ellipse. That is to say:

$$x_0 = \frac{(A-b)(a-x_0) + ka(\sqrt{2ax_0 - x_0^2} - x_0)}{2k(a-x_0)}$$

If we set A as 100 and replace the value of a,k, and b, we get above, x_0 can be solved according to the above equation with some simple manipulation: x_0=288.18. Then substitute the value of x_0 into the elliptic equation we can get the ordinate of tangent point y_0 equal to 82.93410192. We take y_0=83 for the sake of brevity. The potential of resultant makes the urbanization rate reach 100%, while the market force can only make it reach 83%. So the limit of urbanization rate is A=83. Let a=288, we set the point

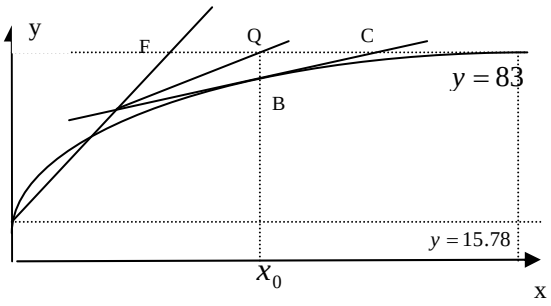

Fig. 5 The limit of urbanization rate

M(288, 83) as the vertex of an ellipse and the corresponding ellipse function can be represented as follows:

$$y = 0.233\sqrt{576.36x - x^2} + 15.78 \qquad (9)$$

B. Forecast to the Changing Tendency of Urbanization Rate

By solving simultaneous equations of (2) and (3) we get:

$$x = \frac{2a(A-b)^2}{k^2a^2 + (A-b)^2} \qquad (10)$$

Then replace A, a, *k* and *b* by its value we get $x = 36$. Correspondingly we obtain $y = 48.38$ from (9). That is the intersection point p(36,48.38) shown in Fig. 6. Based on this calculation, China's urbanization rate will reach 48.38% in 2013. Before 2013, market force is bigger than system force; it means that urbanization is lagged behind because of policies and regulations. To a certain extent, the policies and regulations slow the process of urbanization. 2013 is the inflection point of rapid development of urbanization (this forecast is very coincident with the result of Macroeconomic Blue Book) [6], after 2013, market force will gradually weaken and system forces will promote the development of urbanization instead of slowing the process of urbanization.

According to the above research, the locus function of urbanization rate is the trajectory of the midpoint of elliptical line and straight line (as shown in Figure 6). This trajectory through point P(36, 48.38) and reach its vertex at point G(181, 83). The locus function of urbanization rate

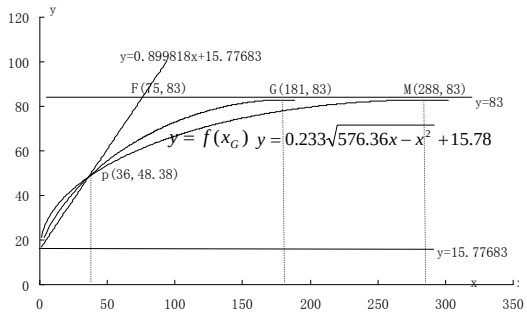

Fig. 6 Diagram of the locus of urbanization rate

can be represented as:

$$y = f(x_G) = f(0.13\sqrt{576.36x - x^2} + 0.5x) \qquad (11)$$

According to the equation (11), urbanization rate in China will reach its limit-83%-in 2158. The points in this trajectory are fit to the equation (7), let's denote $\sqrt{576.36 - x^2}$ as R in (7), and substitution of numerical value of the parameters into formula (7) we can obtain:

$$y = \frac{[0.2330(288.18 - x)R + 518..6190x - 0.8998x^2](259.3095R - 192.1522x - 19353.3840)}{541060.9933x - 809.10054x^2 - 1001.2527xR - 5577258.19} + 15.77683 \qquad (12)$$

By using equation (12) we can simulate the urbanization rate from 2000 to 2009. These calculation results were listed in Table 2 and compared with the actual data.

According to equation (12), we can forecast the urbanization rate in China every five years starting form 2010. The results were listed in Table 3.

TABLE Ⅱ CALCULATION RESULTS AND COMPARISON WITH ACTUAL DATA

year	2000	2001	2002	2003	2004
Calculation results	40.36	40.94	41.51	42.61	43.14
Actual Data	36.22	37.66	39.09	40.53	41.76
year	2005	2006	2007	2008	2009
Calculation results	43.65	44.65	45.14	45.61	46.08
Actual Data	42.99	43.90	44.94	45.68	46.59

TABLE Ⅲ. URBANIZATION RATE TREND FORECAST TABLE (%)

year	x_G	x	$f(x_G)$ forecast value)
2010	33	32	46.53408
2015	38	39	49.51289
2020	43	47	52.535
2025	48	53	54.58897
2030	53	61	57.09582
2035	58	68	59.10492
2040	63	76	61.22093
2045	68	84	63.16942
2050	73	92	64.9703

2055	78	100	66.63925
2060	83	108	68.18888
2065	88	117	69.80234
2070	93	125	71.13043
2075	98	134	72.51426
2080	103	143	73.78936
2085	108	151	74.8372
2090	113	160	75.9252
2095	118	169	76.92196
2100	123	178	77.83189
2105	128	188	78.74565
2110	133	196	79.40579
2115	138	205	80.07578
2120	143	214	80.6711
2125	148	224	81.24748
2130	153	233	81.69151
2135	158	243	82.10366
2140	163	252	82.40276
2145	168	262	82.65643
2150	173	272	82.82819
2155	178	282	82.91868
2156	179	284	82.92706
2157	180	286	82.9322
2158	181	288	82.93411
2159	182	290	82.93279
2160	183	292	82.92823
2165	188	302	82.87761

V. CONCLUSION

From the analysis above, it can be concluded that the development of urbanization in China is faster than that in advanced countries although China's urbanization started rather late. When comparing the urbanization rate data with Britain, France and USA, we can see the results intuitively, as shown in Table 4.

TABLE Ⅳ. URBANIZATION RATE OF CHINA COMPARED WITH BRITAIN, FRANCE AND THE USA

Change interval of urbanization rate	26%～70%	25.5～71.7%	25.7～75.2%
Achieved Years	90	120	120
Achieved Countries	Britain	France	USA
Anticipated achieved years of China	81	88	103
The years of China ahead of other countries	9	12	17

China's urbanization rate the paper predicated is lower than paper [2], [3] predicted. Because when urbanization power (system power and marketability) promotes urbanization, there is a force in the opposite direction which calls Urbanization power back. In the economic development period, urbanization power is significant. Rural infrastructure is enhanced with the further development of economy. Apparent attractiveness of rural areas highlights the Urbanization power back. For example, some city people to the countryside, people yearn for the countryside in Western developed countries and Japan's urbanization rate decreased. All these show the existence of Urbanization power back which is also a market power. China's future system power is to overcome the power. Urbanization power will balance with Urbanization power back on 2158 in china when urbanization rate reaches 82.93411%. Urbanization rate will decrease after that and the rate of decline is slower than the rise.

REFERENCES

[1] National Bureau of Statistics of China (2010). *China Statistical Yearbook:2010*. China Yearbook Press, Beijing.

[2] Pan Jiahua, Wei Houkai (2010). *Annual Report on Urban Development of China*. China Social Sciences Press, Beijing.

[3] Zhong Xiuming, Wu Xueping (2006). *The Driving Force of Urbanization.* China Economy Press, Beijing.

[4] Hu Chunming (2008). "A way to urbanization with Chinese characteristics," *Newsletter About Work in Rural Areas*, No. 1.

[5] Urbanization Process[Z/OL]. http//baike.baidu.com.

[6] China Academy of Social Sciences. Macroeconomic Blue Book [EB/OL]. http://www.cass.net.cn.